Paper ID #41458

Impact of an Experimental Centric Learning on Peer Learning and Collaboration among Environmental Engineering Undergraduates in a Historical Black College and University

Mr. Benjamin Gbeminiyi Famewo, Morgan State University

Benjamin Famewo is a doctoral student in Civil Engineering at Morgan State University. With a interest in structural engineering, Benjamin Famewo is committed to conducting cutting-edge research and making significant contributions to the industry.

Mr. Pelumi Olaitan Abiodun, Morgan State University

Pelumi Abiodun is a current doctoral student and research assistant at the department of Civil Engineering, Morgan State University, Baltimore, Maryland. Pelumi got his BSc and MSc degree in Physics from Obafemi Awolowo University, where he also served as a research assistant at the Environmental Pollution Research unit, in Ile-Ife, Nigeria. As part of his contribution to science and engineering, Pelumi has taught as a teaching assistant both at Morgan State University and Obafemi Awolowo University. With passion to communicate research findings and gleaned from experts in the field as he advances his career, Olaitan has attended several in-persons and virtual conferences and workshop, and at some of them, made presentation on findings on air pollution, waste water reuse, and heavy metal contamination.

Dr. Gbekeloluwa B. Oguntimein P.E., Morgan State University

Dr. Gbekeloluwa B. Oguntimein received his B.S. and Ph.D. degrees in Chemical Engineering from Iowa State University in 1974 and 1979 respectively. He has over 30 years teaching and research experience having taught at in the departments of chemical engin

Dr. Oludare Adegbola Owolabi P.E., Morgan State University

Dr. Oludare Owolabi, a professional engineer in Maryland, joined the Morgan State University faculty in 2010. He is the assistant director of the Center for Advanced Transportation and Infrastructure Engineering Research (CATIER) at Morgan State Universit

Impact of an Experimental Centric Learning on Peer Learning and Collaboration among Environmental Engineering Undergraduates in a Historical Black College and University

Abstract

The world today faces numerous environmental challenges and requires creativity, innovation, and collaboration to resolve these issues. Traditional lecturing methods have limitations in inspiring creativity and learners' collaboration as it is more tutor centered. Experiment-centric learning utilizes hands-on devices and tools to engage students in collaborative and peer learning. This study aims to assess the extent this approach has enhanced peer learning and collaboration among environmental engineering undergraduates. This quantitative investigation was conducted using a pre- and post-test approach. This study used validated items from the popular Motivated Strategies for Learning Questionnaire (MSLQ), signature assignment, and outcome assessment to explore the impact of hands-on devices on peer learning and collaboration as well as academic achievement in modules where this innovative pedagogy was implemented. The data was cleaned and analyzed using SPSS v25.0 (Statistical Package for the Social Sciences), and the results were provided in the form of frequency, percentage, mean, and standard deviation. The study employed a Mid-p Adjusted Binomial and McNemar with a confidence level of 95.0% to explore the impact of mediating socio-demographic variables. There was a significant improvement in the peer-learning and collaboration of the learners ($p<0.050$). In addition, gender and prior academic CGPA were found not to be significantly associated with the increase in peer learning and collaboration ($p>0.05$) while class level was found to be significantly associated ($p<0.05$). The findings of this study contribute valuable insights to the field of environmental engineering education, suggesting that innovative, less cumbersome, easy-to-use technology when combined with teaching methods can enhance peer learning and collaboration. These findings may inform future curriculum design and instructional approaches to better equip students in addressing the complex environmental issues of our era.

Introduction

The world today faces numerous environmental challenges and requires creativity, innovation, and collaboration to resolve these issues. Higher education institutions are the ideal environment for cultivating these essential qualities. However, Historically Black Colleges and Universities (HBCUs) often do not prioritize the development of creativity, innovation, and collaboration in their educational approach for students [1]. Nevertheless, in recognizing the potential impact, there exists a unique opportunity to leverage HBCUs in enhancing diversity, equity, and inclusion in STEM education as well as in the engineering industry. By placing emphasis on nurturing creativity, innovation, and collaboration within the academic environment of HBCUs, students can be better equipped to tackle environmental challenges. This approach not only improves their capacity to discover inventive solutions but also fosters collaboration, which is crucial for tackling intricate problems in the contemporary world [2].

Experimental-centric pedagogy (ECP) is one of the active learning strategies that has been developed and adopted to further improve collaboration and peer learning in STEM education. This approach utilizes low cost and safe hands-on devices to engage students and creates an open space for their minds to explore. It is noteworthy that collaborative learning is essential for developing critical thinking abilities, which has been established in literatures that students remember education material better when working in groups [3],[4].

In the investigation conducted by Cortright [5], the focus was on evaluating the influence of collaborative learning on student retention. The study comprised a cohort of 29 students, with 19 participants assigned to the control group. The outcome underscores the efficacy of active learning methodologies and lends support to the broader discourse on the positive impact of collaborative learning strategies. Cavanagh [6] study shows that students prefer engaging classes with collaborative learning activities such as experimental centric activities. Furthermore, a comprehensive analysis of past studies [7],[8],[9] confirms that collaborative learning structures significantly boost academic performance compared to competitive or individualistic structures competitive or individualistic structures.

This present study aims to assess the extent ECP has enhanced peer learning and collaboration among environmental engineering undergraduates at a Historically Black College and University (HBCU). The rationale behind this study stems from the role that collaborative learning plays in enhancing academic success and professional development, particularly within the context of underrepresented student populations in higher education institutions. Understanding the dynamics of peer learning and collaboration is essential for creating inclusive and supportive learning environments, especially in disciplines like environmental engineering where teamwork and interdisciplinary perspectives are crucial. By examining the effectiveness of this approach within the unique setting of an HBCU, this study aims to contribute valuable insights into tailored educational strategies that promote student engagement, retention, and success. Furthermore, by focusing on underrepresented student populations, this study aligns with broader initiatives aimed at enhancing diversity, equity, and inclusion in higher education.

Theoretical framework of Experimental Centric Pedagogy (ECP)

The process of learning varies among students, making it important for instructors to understand the development of different pedagogical strategies, how to enhance student retention rate, and how to increase student curiosity. In recent years, educational professionals have explored numerous ways individual students gain, retain, and recall information, leading to the creation of various learning theories.

For the purpose of this study, the social learning theory, acronym the 3 Cs of social learning Content, Connect and Collaboration was adopted. The three Cs derived from Albert Bandura [10] serve as the foundation for crafting a pedagogical approach that effectively supports students' social learning. The theory [10] emphasizes on cognitive and behavioral aspects of learning, offering a comprehensive framework that mirrors real-world learning experiences.

The social learning theory states that knowledge is acquired through the following principles [11], [12].

- Learning is cognitive and social, not just behavioral.
- Learning occurs by behavior observation and their consequences (vicarious reinforcement).
- Learning involves observation, information extraction, and decision-making,
- Learning is an active interaction where cognition, environment, and behavior mutually influence each other (reciprocal determinism).

Social learning theory using the 3C Model:

This study incorporates the 3C model of social learning [13] and it is defined as Content, Connection, and Collaboration. In the learning field, content creation is crucial to achieve precise learning. Instructors should create content by setting learning objectives for effective training [14]. The integration of a social learning aspect requires the instructors to clearly state the desired learning outcomes while concurrently establishing a social context within the learning environment. This entails encouraging learners to connect and collaborate with peers, be it through formal avenues such as group projects or mentoring programs [10].

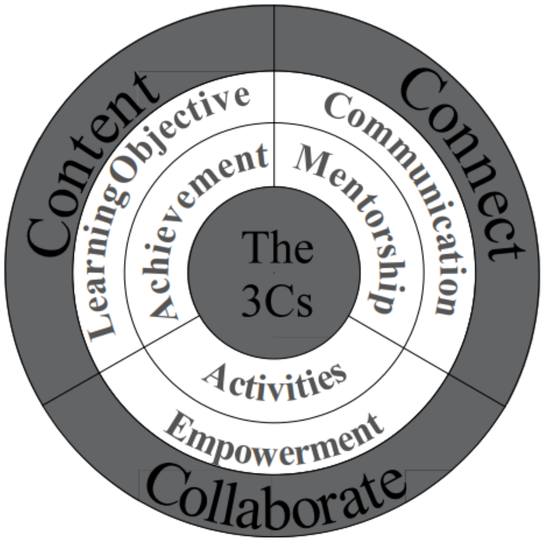

Figure 1: The 3Cs Framework [13].

The emphasis on connection in social learning highlights the importance of instructors not only facilitating student interaction during traditional lectures or lab sessions but also fostering online activities [15]. Instructors should establish a mentorship environment within the classroom, encouraging students to learn not only from the instructors but also from each other. This reciprocal learning benefits both students and mentors through reinforced learning. This deliberate shift in strategy aims to broaden access to educational content, promoting meaningful discussions through dedicated platforms like discussion forums [16]. This approach is particularly relevant in specialized courses such as Environmental Engineering.

Collaboration within social learning is very crucial, as it deepens engagement. Instructors can proactively encourage learners to collaborate by facilitating group projects, discussions, or problem-solving activities [17]. This collaborative approach empowers learners to share experiences, enrich each other's understanding, and collectively achieve common goals. Whether through meticulously designed discussion forums or seamlessly integrated group projects, collaboration serves as a linchpin in enhancing the overall social learning experience for undergraduate students.

Methodology

This study aimed to assess the impact of experiment-centric pedagogy (ECP) on learners' peer learning and collaboration. To assess the impact, experiments were conducted in CEGR 388: Environmental Engineering I, employing the ECP approach. The module developed was centered on the hands-on detection and measure of pH as well as the determination of total dissolved solids in home or domestic liquids. The assessment of peer learning and collaboration was carried out using the validated Motivated Strategy for Learning Questionnaire (MLSQ) by Pintrich [18]. Additionally, signature assignments were used to evaluate the enhancement of collaboration facilitated by the employed pedagogy. It is essential to note that, although the MLSQ consists of various constructs, this paper only reports peer learning and collaboration items.

Module Design

Figure 2 shows the well-developed modulus structure and how the Experimental Centric Pedagogy was deployed. This has been given a detailed explanation by Fibrined et al [19].

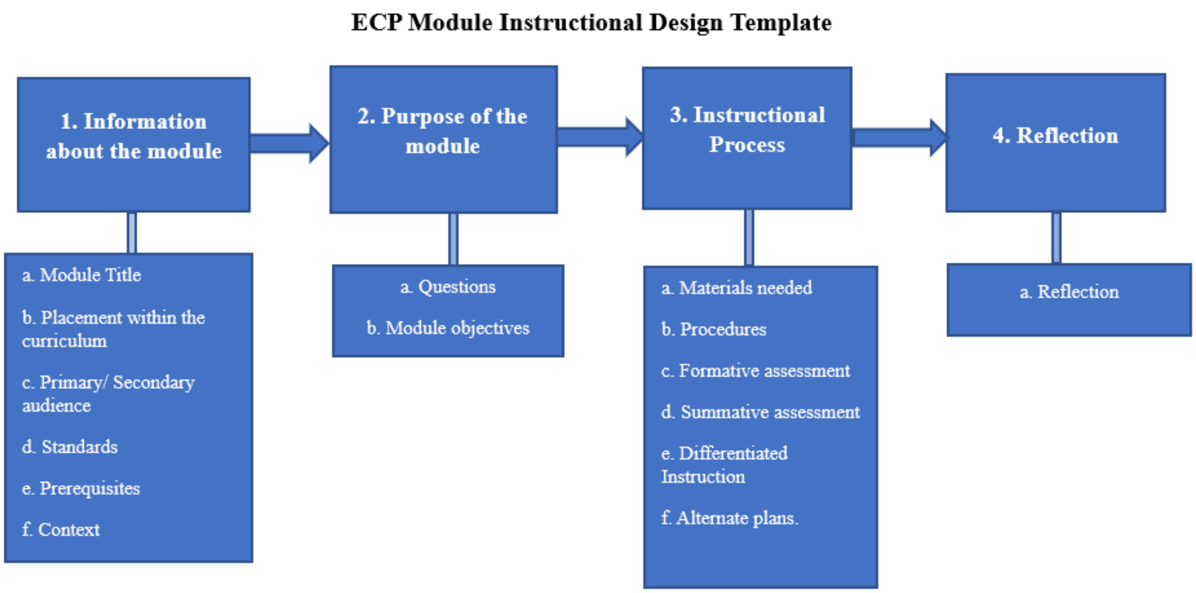

Figure 2**:** ECP Instructional module design [19].

CEGR 338 introduces students to the planning and design of elements of water treatment plants and elements of wastewater treatment plants, and the design of sewers and water distribution system hydraulics. The ECP laboratory experiment applies the knowledge of general chemistry to sanitary chemical analyses, which include pH measurements and total dissolved solids.

Hands-on Activity during Module Implementation

The pH Experiment:
This experiment utilizes ADALM 1000, Analog pH Sensor kit which contains pH meter, buffer solution and other solutions such as lemon juice, vinegar, water, soda, vinegar, bleach. Figure 3 and Figure 4 show the equipment used for the experiments. The goal of this experiment is to explain the relationship between pH and hydrogen ions to the students and to test the acidity and

basicity of different solutions. The mathematical relationship between pH and hydrogen ions is represented in equation 1

$$pH = -\log(H+) \quad (1)$$

This can be interpreted as if the pH increases, the hydrogen ion in the solution increases and vice versa. Students were expected to check the pH number of each solution using pH meter and the ADALM 1000. At the end of the experiment students had a more informed understanding of different solutions' acidity and basicity.

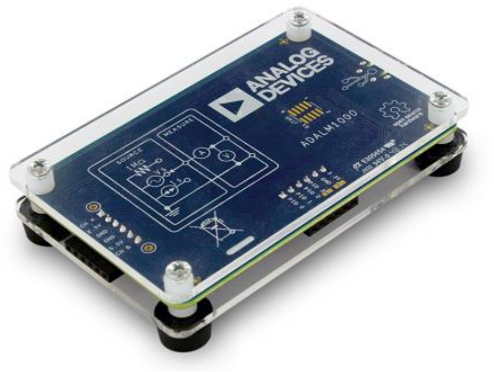

Figure 3: ADAM 1000

Figure 4: Analog pH kit

Data collection and analysis

The study adopted a pre-post-test design approach and data collection was done prior to the implementation of each module. Noteworthy is that each module was implemented in separate terms and hence the uniqueness of participants was ensured in each term. Ethical consideration in terms of privacy and consent was established and ensured during the study. Survey was sent digitally to the students prior to the implementation and after the implementation of the module using Motivated Strategies for Learning Questionnaire (MSLQ). The collected data was screened for missing data and consistency of assigned identification was ensured at pre and post-test data. This enables comparison of students' responses and performance on the survey and signature assignments. This current study used the data collected between the fall terms of 2021 and the spring of 2023. Moreover, the peer learning and collaboration instrument used in the study is a 7-point Likert scale, 3 item instrument (Table 1). The range of the scoring items was from 1 (not very true of me) to 7(very true of me). The normality test of the cleaned data was conducted to ensure the best choice of descriptive and inferential analysis. The normality test revealed that the null hypothesis was accepted ($p<0.05$). Descriptive statistics and inferential analysis were conducted on the merged cleaned data from pre-and post-test using the unique identification number. The Box-and-Whisker plots, mean, standard deviation, and percentage were adopted as the descriptive statistical approach to evaluate the baseline and potential impact of the pedagogy. In addition, the non-parametric z-test was also conducted as well as the Cohen's d effect test was carried out to determine the significance of the implementation of this pedagogy on the students. Inferential statistics were conducted at a confidence level set at 95%.

Table 1: MSLQ Construct- Peer Learning/Collaborating (PLC)

PLC_1 - When studying for this course, I often try to explain the material to a classmate or a friend
PLC_2 - I try to work with other students from this class to complete the course assignments.
PLC_3 - When studying for this course, I often set aside time to discuss the course material with a group of students from the class.

Results

The study involved twenty-nine (29) participants. The result as seen on Table 2 illustrates the social demographics of the learners, which shows 72.4% of the learners were male and 75.9% of the learners are seniors. Notably, the study was conducted at an HBCU, highlighting the importance of examining educational interventions within diverse academic settings [20], given the inclusive culture fostered by HBCUs [21].

Table 2: Learners Social Demographic

	Frequency, N=29	**Percentage**
Self-Identify Gender		
Female	8	27.6%
Male	21	72.4%
Academic level		
Junior	7	24.1%
Senior	22	75.9%

The result presented in figure 5 indicates that there was a reduction in the interquartile ranges of the scores on peer learning and collaboration of the students. Particularly, there was an evident positive shift in two constructs (PLC_2 and PLC_3), “I try to work with other students from this class to complete the course assignments,” and “When studying for this course, I often set aside time to discuss the course material with a group of students from the class.” The adoption of a strategy to engage fellow students by discussion revealed that students demonstrated a collaborative attitude towards peer engagement post-implementation of the pedagogy. In addition, the minimum scores in all the items were increased when the whiskers of the figures are considered revealing that the impact of the pedagogy extended to a level to all groups of students that participated in the study.

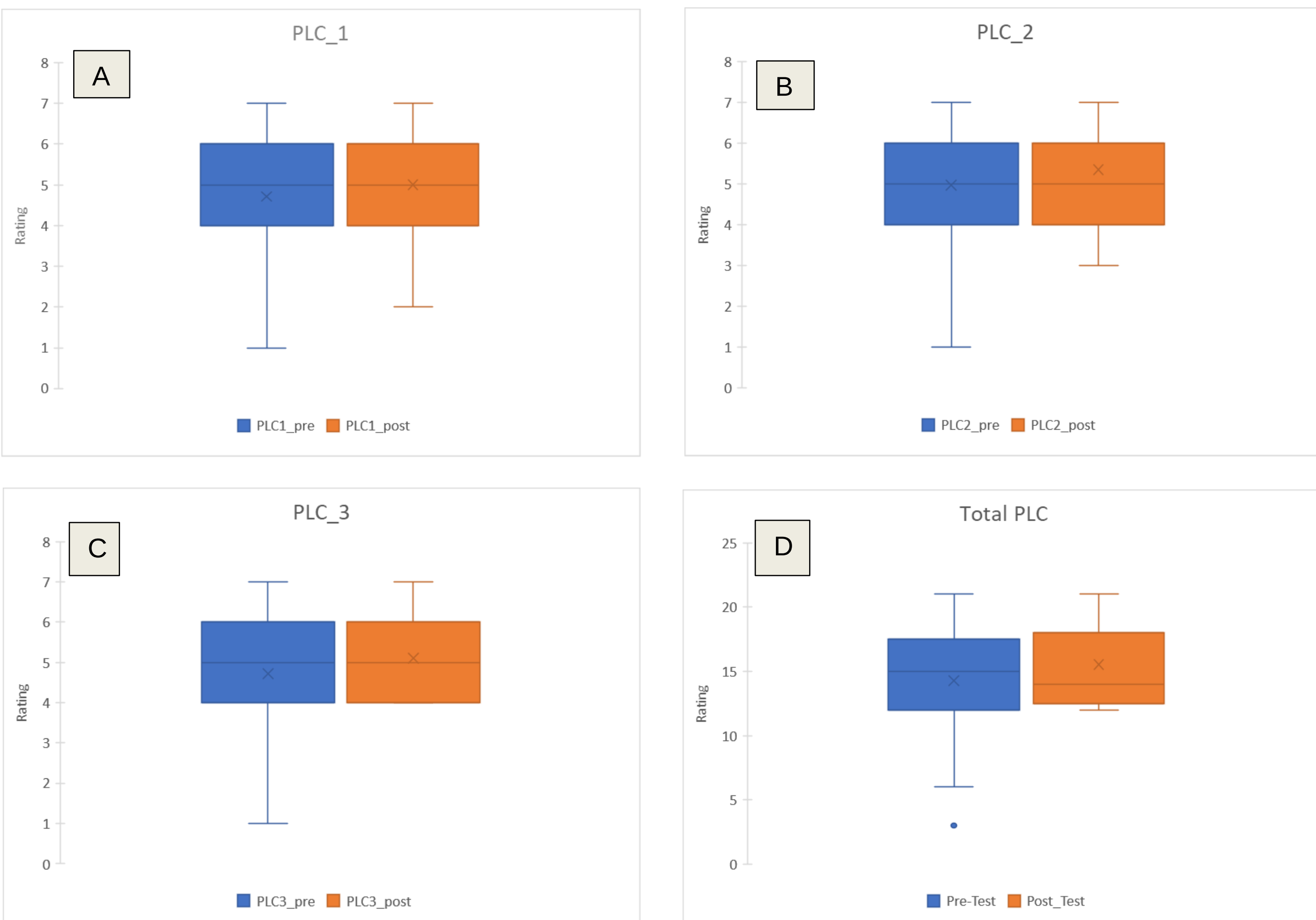

Figure 5: Box-Whisker Plots of Pre-and Post-Test Scores on Peer Learning and Collaboration

Figure 6 shows a bar graph that represents the percentage change in mean scores from pre-test to post-test for three different constructs (PLC_1, PLC_2, and PLC_3). The most significant increase was observed in PLC_1, with an approximate 11% rise in mean scores. This substantial growth suggests that students experienced notable improvements in the aspects of peer learning and collaboration measured under this construct. Also, PLC_2 and PLC_3 also exhibited positive changes, albeit less pronounced than PLC_1. They recorded roughly 7% and 8% increases respectively, indicating that the experimental centric approach also positively impacted these areas of peer learning and collaboration. The overall percentage change across all constructs was around 9%. This suggests a general enhancement in peer learning and collaboration underscores the effectiveness of the experimental centric approach in fostering a more collaborative learning environment.

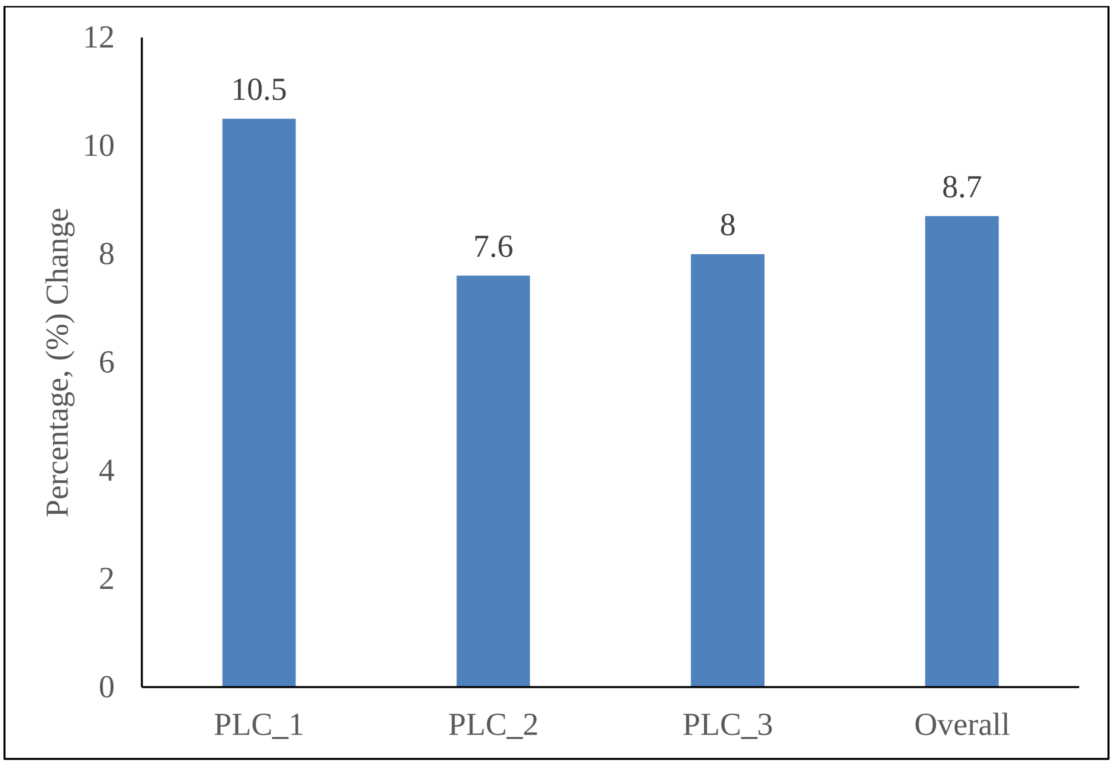

Figure 6: Graph of percentage change of mean of pretest and posttest score.

Table 4 shows the result of the sample test of retest and protest on peer learning and collaboration, the Mid-p Adjusted Binomial and McNemar tests. Both tests were conducted to compare the pre-test and post-test proportions. Mid-p adjusted binomial test shows a difference in proportions of -0.207 with an asymptotic standard error of 0.075. The one-sided p-value is 0.008, and the two-sided p-value is 0.016. Given that all p-values are below the common alpha level threshold (e.g., 0.05), we reject the null hypothesis that there is no significant difference between pre- and post-tests scores. The negative difference in proportions indicates a decrease from pre-test to post-test scores.

McNemar's test indicated a difference in proportions of -0.207 with an asymptotic standard error of 0.075 as well but yielded a Z value of -2.449, resulting in one-sided p-value of 0.007 and two-sided p-value of 0.014. Again, given that all p-values are below the common alpha level threshold (0.05), we reject the null hypothesis that there is no significant difference between pre- and post-tests scores. The consistency in results across different testing methods strengthens our confidence in these findings, suggesting that an intervention or treatment administered between these two tests had a statistically significant effect on participants' scores.

The paired-samples proportions tests further validate our findings, revealing statistically significant differences between pre-test and post-test scores across all PLC constructs ($p < 0.05$). Specifically, the mid-p adjusted binomial test and McNemar test indicate a significant improvement in peer learning and collaboration following the intervention.

Table 4: Paired-Samples Proportions Tests

	Test Type	Difference in Proportions	Asymptotic Standard Error	Z	Significance One-Sided p	Significance Two-Sided p
Pretest - Posttest	Mid-p Adjusted Binomial	-.207	.075		.008	.016
	McNemar	-.207	.075	-2.449	.007	.014

The study examines the association between the level of peer learning at pre- post-test (high or low) and socio-demography variables (gender, current CGPA, and academic level). The result showed that at pre-test, there was no significant association between the level of PLC and the socio-demography. However, at post-test, there was a significant association between the level of PLC and the academic level of the students.

Table 5: Association Between Socio-Demography Variables and Peer Learning and Collaboration Scores

Pre-Test PLC				
Gender	Low	High	Chi-Square (χ^2)	*p*-value
Female	3(23.1)	5(31.3)	0.24	0.62
Male	10(76.9)	11(68.8)		
Current CGPA				
3.6-4.0	4(30.8)	5(31.3)	3.62	0.31
31.-3.5	2(15.4)	7(43.8)		
2.6-3.0	6(46.2)	3(33.3)		
2.1-2.5	1(7.7)	1(6.3)		
Academic Level				
Junior	3(23.1)	4(25.0)	0.014	0.91
Senior	10(76.9)	12(54.5)		
Post-Test PLC				
Gender				
Female	2(18.2)	6(33.3)	0.79	0.38
Male	9(81.8)	12(66.7)		
Current CGPA				
3.6-4.0	4(36.4)	5(27.8)	4.22	0.24
31.-3.5	1(9.1)	8(44.4)		
2.6-3.0	5(45.5)	4(22.2)		
2.1-2.5	1(9.1)	1(5.6)		
Academic Level				
Junior	5(71.4)	2(11.1)		
Senior	6(27.3)	16(88.9)	4.39	0.04*

Discussion

The result of this study indicate a greater proportion of male students in the field of environmental engineering, aligning with the research conducted by Takahira et al [22]. Takahira's research suggests that male students are commonly expected to pursue careers in environmental engineering. This alignment underscores the consistency between the present study's results and previous research findings regarding gender distribution in environmental engineering disciplines.

According to from Bandura’s social learning theory [10], which emphasizes the significance of observational learning and social interactions in the learning process, students demonstrate enhanced peer learning and collaboration in experimental centric learning approach. The observed marginal increase in mean scores from pre-test to post-test further supports the principles of Bandura's theory[10], highlighting the efficacy of peer-based learning approaches in academic settings.

Additionally, the result from Melnyk [23] illuminate the beneficial effects of the experimental-centric approach on peer learning dynamics, it demonstrates that this approach proves more effective in fostering students' interest and achievement in mastering challenging mathematical concepts compared to traditional peer teaching methods. These results underscore the potential of experimental-centric methodologies in nurturing collaborative learning environments that promote student engagement and academic success.

The consistency of results across multiple test strengthens the soundness of these findings, implying that an intervention between the two tests had a statistically significant influence on the participants' scores. Pair-samples proportions tests revealed significant differences in pre-test and post-test scores for all peer learning and collaboration ($p < 0.05$), supporting our findings. Specifically, both the mid-p adjusted binomial test and the McNemar test showed a significant improvement in peer learning and collaboration after the intervention. These results underscore the efficacy of the intervention in enhancing peer learning and collaboration among participants, thereby contributing to the growing body of literature on effective educational interventions in academic settings.

Although the experimental-centric learning approach enhances peer learning and collaboration, additional analysis is necessary to comprehensively gauge its long term impact. Incorporating a control group would provide a more robust means of measuring the efficacy of this approach.

Conclusion

This study provides evidence supporting the impact of an experiment-centric approach in environmental engineering education. Over the period from Fall 2021 to Spring 2023, we implemented this approach, utilizing a validated instrument for assessment. The results from the post-test administered to students indicate that this experiential-centric approach not only facilitated peer learning but also significantly enhanced collaboration among learners. Furthermore, the approach empowered students to explore and innovate, as reflected in their heightened level of collaboration. The findings emphasize the significance of integrating experiential learning methods into environmental engineering education to enhance active engagement and skill development among students. Importantly, these results hold broader implications for educational practices, highlighting the crucial role of hands-on, experiential learning methodologies in nurturing collaborative skills vital for the future success of engineering professionals. The limitation identified was the use of a single group for this experimental study as well as the small sample size.

Acknowledgement

This study is part of the work that was supported by the National Science Foundation Grant # 1915615, titled “Adapting an Experiment-centric Teaching Approach to Increase Student Achievement in Multiple STEM Disciplines”. It should be noted that the opinions, results and conclusions or recommendations expressed are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

[1] F. Commodore, M. Gasman, C. Conrad, and T.-H. Nguyen, “Coming Together: A Case Study of Collaboration Between Student Affairs and Faculty at Norfolk State University,” *Front. Educ.*, vol. 3, May 2018, doi: 10.3389/feduc.2018.00039.

[2] O. S. Tan, *Problem-based Learning Innovation: Using Problems to Power Learning in the 21st Century*. Thomson, 2003. [Online]. Available: https://books.google.com/books?id=-_TinQEACAAJ

[3] M. Laal and M. Laal, “Collaborative learning: what is it?,” *Procedia - Soc. Behav. Sci.*, vol. 31, pp. 491–495, 2012, doi: 10.1016/j.sbspro.2011.12.092.

[4] K. A. Smith, “Cooperative learning: Making" groupwork" work,” *New Dir. Teach. Learn.*, pp. 71–82, 1996.

[5] R. N. Cortright, H. L. Collins, D. W. Rodenbaugh, and S. E. DiCarlo, “Student retention of course content is improved by collaborative-group testing,” *Adv. Physiol. Educ.*, vol. 27, no. 3, pp. 102–108, 2003.

[6] M. Cavanagh, “Students’ experiences of active engagement through cooperative learning activities in lectures,” *Act. Learn. High. Educ.*, vol. 12, no. 1, pp. 23–33, Mar. 2011, doi: 10.1177/1469787410387724.

[7] C. J. Roseth, D. W. Johnson, and R. T. Johnson, “Promoting early adolescents’ achievement and peer relationships: The effects of cooperative, competitive, and individualistic goal structures.,” *Psychol. Bull.*, vol. 134, no. 2, pp. 223–246, 2008, doi: 10.1037/0033-2909.134.2.223.

[8] M. A. Qureshi, A. Khaskheli, J. A. Qureshi, S. A. Raza, and S. Q. Yousufi, “Factors affecting students’ learning performance through collaborative learning and engagement,” *Interact. Learn. Environ.*, vol. 31, no. 4, pp. 2371–2391, May 2023, doi: 10.1080/10494820.2021.1884886.

[9] D. W. Johnson, R. T. Johnson, and K. A. Smith, “Cooperative Learning Returns To College What Evidence Is There That It Works?,” *Chang. Mag. High. Learn.*, vol. 30, no. 4, pp. 26–35, Jul. 1998, doi: 10.1080/00091389809602629.

[10] A. Bandura, *Social learning theory*. Oxford, England: Prentice-Hall, 1977.

[11] J. E. Grusec, “Social learning theory and developmental psychology: The legacies of Robert Sears and Albert Bandura.,” *Dev. Psychol.*, vol. 28, no. 5, pp. 776–786, Sep. 1992, doi: 10.1037/0012-1649.28.5.776.

[12] T. L. Rosenthal and B. J. Zimmerman, *Social learning and cognition*. Academic Press, 2014.

[13] H. Fuks, "The 3C Collaboration Model," no. January, 2008.
[14] K. Göbel and A. Helmke, "Intercultural learning in English as foreign language instruction: The importance of teachers' intercultural experience and the usefulness of precise instructional directives," *Teach. Teach. Educ.*, vol. 26, no. 8, pp. 1571–1582, Nov. 2010, doi: 10.1016/j.tate.2010.05.008.
[15] K. E. Matthews, V. Andrews, and P. Adams, "Social learning spaces and student engagement," *High. Educ. Res. Dev.*, vol. 30, no. 2, pp. 105–120, Apr. 2011, doi: 10.1080/07294360.2010.512629.
[16] C. Hill-Carter, "The Effects of Teacher Mentoring on Teacher Retention," no. May, p. 165, 2010.
[17] R. Ferguson and S. B. Shum, "Social learning analytics: Five approaches," *ACM Int. Conf. Proceeding Ser.*, no. December, pp. 23–33, 2012, doi: 10.1145/2330601.2330616.
[18] P. R. Pintrich and E. V. De Groot, "Motivational and Self-Regulated Learning Components of Classroom Academic Performance," *J. Educ. Psychol.*, vol. 82, no. 1, pp. 33–40, 1990, doi: 10.1037/0022-0663.82.1.33.
[19] T. O. Ibirinde *et al.*, "Work in Progress: Using Experiment-centric Learning Pedagogy to Increase Student Understanding of Chemical Principles and Concepts," *ASEE Annu. Conf. Expo. Conf. Proc.*, 2023.
[20] O. Lee and J. Krajcik, "Large-scale interventions in science education for diverse student groups in varied educational settings," *J. Res. Sci. Teach.*, vol. 49, no. 3, pp. 271–280, Mar. 2012, doi: 10.1002/tea.21009.
[21] C. A. George Mwangi, "Exploring Sense of Belonging among Black International Students at an HBCU," *J. Int. Students*, vol. 6, no. 4, pp. 1015–1037, Oct. 2016, doi: 10.32674/jis.v6i4.332.
[22] S. Takahira, D. J. Goodings, and J. P. Byrnes, "Retention and Performance of Male and Female Engineering Students: An Examination of Academic and Environmental Variables," *J. Eng. Educ.*, vol. 87, no. 3, pp. 297–304, Jul. 1998, doi: 10.1002/j.2168-9830.1998.tb00357.x.
[23] C. Melnyk, "Improving Elementary School Mathematics Instruction with Principal Coaching and Peer Collaboration: A Pilot Experimental Study," Fordham University PP - United States -- New York, United States -- New York, 2020. [Online]. Available: http://proxy-ms.researchport.umd.edu/login?url=https://www.proquest.com/dissertations-theses/improving-elementary-school-mathematics/docview/2384570879/se-2?accountid=12557